ECEN 150 Lab 3 – KVL and KCL

Name:

Purposes:

- Experimentally demonstrate KCL: Kirchoff's Current Law
- Experimentally demonstrate KVL: Kirchoff's Voltage Law
- Improve breadboarding skills.
- Learn new ways to measure circuit currents.

Background:

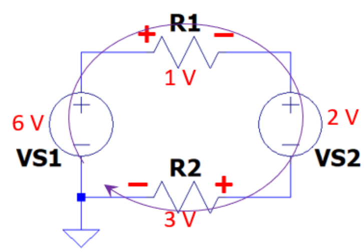
Kirchoff's Current Law (KCL) states that the sum of currents going *into* a node equals the sum of currents *out* of the node:

$$\textbf{KCL: } i_{in,total} = i_{out,total} \rightarrow i_{in,total} - i_{out,total} = 0 \text{ A}$$

Kirchoff's Voltage Law (KVL) states that the sum of voltages around a loop equals zero. In other words, the sum of voltages *dropped* equals the sum of voltages *generated*:

$$\textbf{KVL: } v_{dropped,total} = v_{generated,total} \rightarrow v_{dropped,total} - v_{generated,total} = 0 \text{ V}$$

As an example, consider the circuit below. Starting at ground and going clockwise around the loop we add up all voltages. If we encounter a "-" sign of an element first as we go around the loop, that voltage is considered "generated" and therefore negative. If we encounter a "+" sign first, that voltage is dropped and therefore positive:



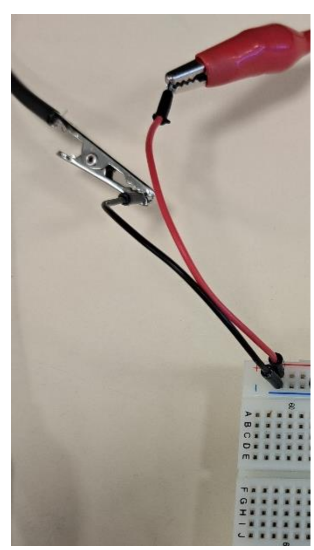
$$-V_{S1} + V_{R1} + V_{S2} + V_{R2} = 0 \text{ V}$$

$$-6 \text{ V} + 1 \text{ V} + 2 \text{ V} + 3 \text{ V} = 0\text{V}$$

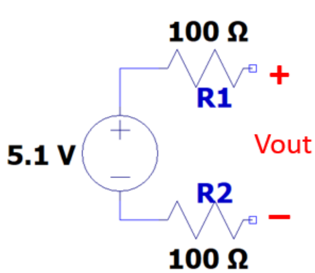
Procedure:

Part 1. KVL on an open circuit

Step 1: Construct the circuit.



- Grab three 100 Ω resistors (two used now; the third used later).
- Construct the circuit below.
  - Use a breadboard. Connect the power supply to one pair of supply rows (see picture).
  - Connect the resistors as illustrated in the schematic.



Step 2: Measure all voltages.5.

- Using a voltmeter, measure each of the voltages in the table below, and record the values. (4 points)

Voltage	Measured value
The voltage source (at the breadboard connection)	5.1V
V_{R1}	0V
V_{R2}	0V
Vout	5.1V

- **Question 1:** Explain your measured V_{R1} and V_{R2} values using Ohm's Law. (3 points)

V=iR. The voltage across the resistor is 0 because there is 0 current. 0A*100ohms = 0V

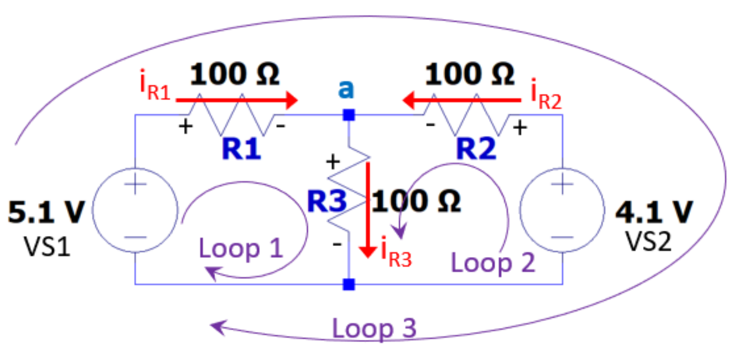
- **Question 2:** Using KVL and your answer from Question 1, explain why Vout matches the source voltage. (3 points)

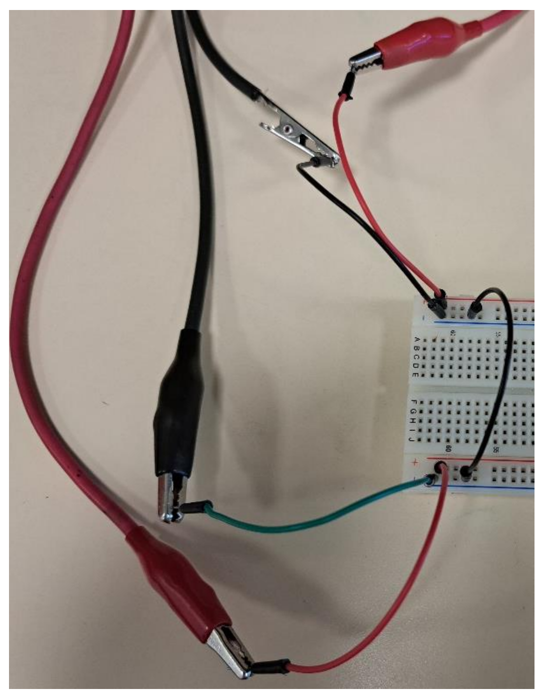
The voltage in must equal the voltage out, so the difference between them would be 0. Because there is no current, there wouldn't be a voltage drop across the resistor, so the total voltage between the two of them would equal the voltage source.

Part 2. KVL on a multi-loop resistor circuit

Step 1: Construct the circuit.

- Construct the circuit below on a breadboard.
  - Assign one breadboard supply pair to supply VS1 and the other to supply VS2, as shown in the photo.
  - Ensure that the ground side of both supplies are connected together, as shown in the photo.





- **Important:** if the current limit of your supplies is less than what the circuit needs, it will enter a "constant current" mode (CC) and the output voltage will drop below your set value.
    - **Check for the "CC" light**. If it's on (see photo), increase the available current by turning the "current" knob slightly clockwise. The "Constant Voltage" light (CV) should then turn on and CC light turn off.

Step 2: Prove KVL

- **Question 3:** Write a **KVL expression** for each of the 3 loops shown in the schematic in terms of the variables V_{R1}, V_{R2}, V_{R3}, VS1, and VS2 as relevant. **Don't use numeric values**; just the variable names. *Watch "+" and "-" carefully.

  Loop 1**:** (2 points)

  0 = VR1 + VR3 – VS1

  Loop 2**:** (2 points)

  0= VR2 + VR3 – VS2

  Loop 3**:** (2 points)

  0= VR1 - VR2 + VS2 – VS1

- Measure each of the values in the table below and enter the measured values. (5 points)

Voltage	**Measured value** (*all measured values should be positive)
VS1 (at the breadboard connection)	5.3V
VS2 (at the breadboard connection)	4.0V
V_{R1}	2.2V
V_{R2}	0.9V
V_{R3}	3.1V

- **Question 4:** Replace the voltage variables from your equations in Question 3 with the **measured values** from the table above. Ensure that KVL is valid for each loop (within reasonable error).

  Loop 1: (2 points)

  0 = 2.2V + 3.1V – 5.3V

Loop 2: (2 points)

0 = 0.9V + 3.1V – 4.0V

Loop 3: (2 points)

0 = 2.2V – 0.9V + 4.0V – 5.3V

Part 3. KCL on the same circuit

Step 1:

- **Question 5:** Using the same circuit from Part 2, write the KCL equation for node "a" in terms if iR1, iR2, and iR3 (**no numeric values yet**).

  KCL at node "a": (3 points)

  0 = iR1 + iR2 – iR3

- Enter the actual values of each current in the table below. *You will **not** use the multimeter. Instead, use the current measured by the power supply or Ohm's Law, as indicated. (3 points)
  - *The voltage sources indicate the current they are supplying on the digital display.

Current	**Measured value** (*all measured values should be positive)
i_{R1} (as measured by the voltage source)	0.022A
0.026i_{R2} (as measured by the voltage source)	0.009A
i_{R3} (use Ohm's Law: V_{R3} / R3; use your measured V_{R3} value from Part 2)	0.031A

- **Question 6:** Show that KCL is valid by replacing the variables from Question 5 with your measured current values from the table above: (3 points)

  0 = 0.022A + 0.009A – 0.031A

*****To pass off your circuit, demo it to the TA or instructor and take Lab 3: Quiz 1*****

Part 4. Conclusions statement.

Write a brief conclusions statement that discusses all of the original purposes of the lab. Please use complete sentences and correct grammar to express your thoughts on how you fulfilled the purposes of the lab:

Purposes (repeated):

- Experimentally demonstrate KVL.
- Experimentally demonstrate KCL.
- Improve breadboarding skills.
- Learn new ways to measure circuit currents.

1. How did you demonstrate KVL today?
2. How did you measure the currents without using the current function of the multimeter?
3. How did you demonstrate KCL today?

4. Were there any small discrepancies in your KVL or KCL equations after plugging in measured values? If so, what was the cause of those? (*Consider the precision of the current reported by the power supply and the tolerance of the resistor values).

Conclusions (10 points):

1. In each of the loops in our circuit we showed that the voltage into the loop was the same as what was leaving the loop. By measuring the voltage across each element in the circuit, we went through it one by one adding/subtracting each source based on its polarity to show the voltage out equaled the voltage in
2. We measured the current by using Ohm's law instead. If you know the voltage and resistance, you can calculate the current. i = V/R
3. We showed that through node "a", the two currents coming into the node equaled the one current leaving it. By calculating the current from Ohm's law, we set up the equation that showed iR1 + iR2 = iR3 and the numbers checked out.
4. Initially, there were small discrepancies, but after the voltage source stopped fluctuating we got more accurate measurements and the values worked out well. The discrepancies could be due to the resistors not being exactly 100 ohms, the power supply changing and readings changing, the connection between wires may not have been perfect, or connection with the multimeter and the multimeter itself, or that we rounded our values.

Congratulations, you have completed Lab!
You may now submit this document.